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BIOCHEMISTRY

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THE MOLECULAR BASIS
OF CELL STRUCTURE AND FUNCTION

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WORTH PUBLISHERS, INC.

For Jan

BIOCHEMISTRY, Second Edition

by Albert L. Lehninger

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polypeptide chain (page 345). In some cases, however, the coenzyme is only loosely bound and essentially functions as one of the specific substrates of that enzyme.

Chemical Kinetics

Before we examine the catalysis of reactions by enzymes, some relationships and terms used in measuring and expressing the rates of chemical reactions must be outlined. Chemical reactions may be classified on the basis of the number of molecules that must ultimately react to form the reaction products. Thus, we have monomolecular, bimolecular, and termolecular reactions, in which one, two, or three molecules, respectively, undergo reaction.

Chemical reactions are also classified on a kinetic basis, by reaction order, and we have zero-order, first-order, second-order, and third-order reactions, depending on how the reaction rate is influenced by the concentration of the reactants under a given set of conditions.

First-order reactions are those which proceed at a rate exactly proportional to the concentration of one reactant (Figure 8-2). The simplest example is when the rate of the reaction

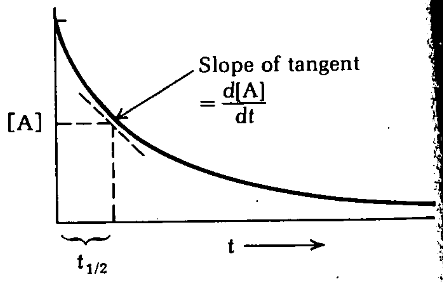
$$A \longrightarrow P$$

is exactly proportional to the concentration of A. Then the reaction rate at any time t is given by the first-order rate equation

$$\frac{-d[A]}{dt} = k[A]$$

where [A] is the molar concentration of A and $-d[A]/dt$ is the rate at which the concentration of A decreases. The proportionality constant k is called the rate constant or specific reaction rate. First-order rate constants have the dimensions of reciprocal time, usually s^{-1}.

Figure 8-2
Plot of the course of a first-order reaction. The half-time $t_{1/2}$ is the time required for one-half of the initial reactant to be consumed.



The integrated form of this equation, which is more useful for carrying out kinetic calculations, is

$$\log \frac{[A_0]}{[A]} = \frac{kt}{2.303}$$

in which $[A_0]$ is the concentration of A at zero time and [A] is the concentration at time t.

In first-order reactions, the half-time $t_{1/2}$ of the reaction is given by

$$t_{1/2} = \frac{0.693}{k}$$

a relationship that is simply derived. In first-order reactions the half-time is independent of the initial concentration of substrate.

Second-order reactions are those in which the rate is proportional to the product of the concentrations of *two* reactants or to the second power of a single reactant. The simplest example is the reaction

$$A + B \longrightarrow P$$

The rate of this reaction, which may be designated as $-d[A]/dt$, $-d[B]/dt$, or $+d[P]/dt$, is proportional to the product of the concentrations of A and B, as given by the second-order rate equation

$$\frac{-d[A]}{dt} = k[A][B]$$

where k is the second-order rate constant. If the reaction has the form

$$2A \longrightarrow P$$

and its rate is proportional to the product of the concentration of the two reacting molecules, the second-order rate equation is

$$\frac{-d[A]}{dt} = k[A][A] = k[A]^2$$

The rate constants of second-order reactions have the dimensions 1/(concentration × time), or M^{-1} s^{-1}. The integrated form of the second-order rate equation is

$$t = \frac{2.303}{k([A_0] - [B_0])} \log \frac{[B_0][A]}{[A_0][B]}$$

where $[A_0]$ and $[B_0]$ are initial concentrations and [A] and [B] the concentrations at time t.

For second-order reactions in which the initial concentrations of the reactants are equal, the half-time is equal to $1/C_0k$, where C_0 is the initial concentration of reactants and k the second-order rate constant.

It is important to note that a second-order reaction such as

$$A + B \longrightarrow P$$

may under some conditions *appear* to be a first-order reaction. For example, if the concentration of B is very high and that of A very low, this reaction might appear to be first-order because its rate will be nearly proportional to the concentration of only one reactant, namely, A. Under these special conditions the reaction is an apparent- or pseudo-first-order reaction.

Third-order reactions, which are relatively rare, are those whose velocity is proportional to the product of three concentration terms. Some chemical reactions are independent of the concentration of any reactant; these are called zero-order reactions. Many catalyzed reactions are zero order with respect to the reactants. When this is true, the rate of reaction depends on the concentration of the catalyst or on some